KEK

APPLICATION of ELECTRO CHEMICAL BUFFING onto NIOBIUM SRF CAVITY SURFACE

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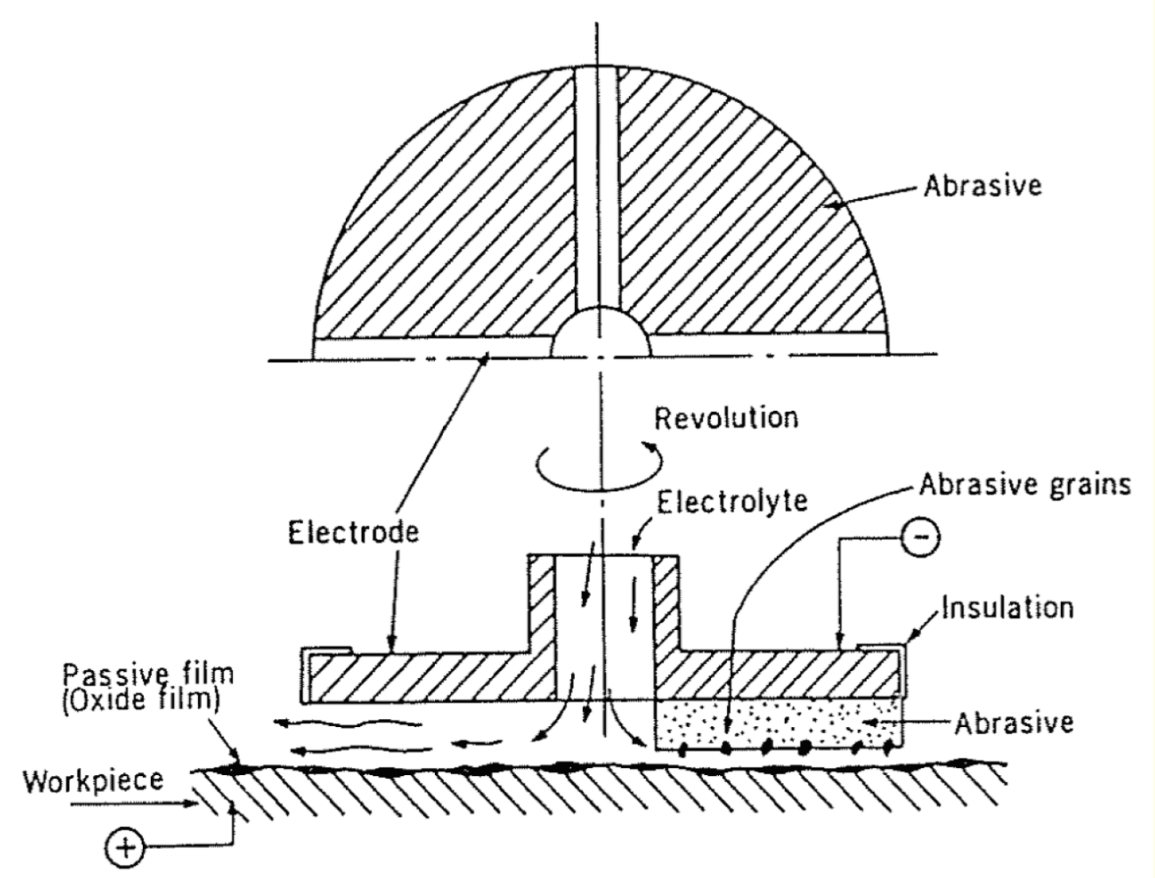
Outline

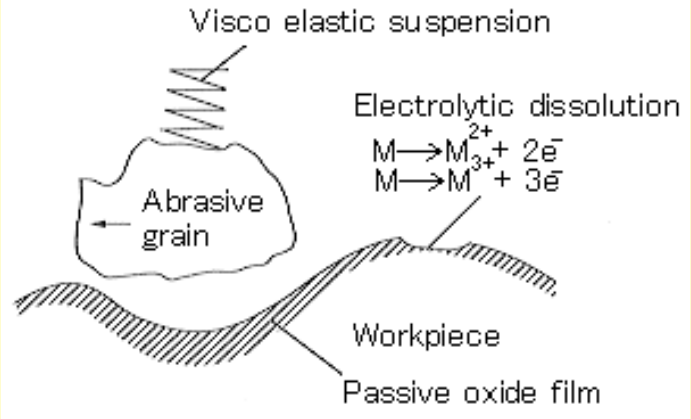
- Aim of Study
- Principle of ECB Treatment and Its Facility
- Comparison of EP and ECB Treatment Technologies
- Characterization of EPed and ECBed Surface
- Application of ECB to 1.3GHz Nb Single Cell Cavity
- Summary

Aim of Study

- Today's electropolishing (EP) is generally considered to be the best technology for niobium SRF cavities.
- However, hydrofluoric and sulfuric acid mixture usually used in EP process is harmful and requires carefully controlled handling of it and the many additional facilities.
- A good number of production cost is able to reduce when any other technology that is simpler with highly efficiency and with simpler facilities of polishing, bringing us equivalent or better performance compared with EP.
- Electrochemical buffing (ECB) that is quite eco-friendly is one of possibilities to realize this idea. In viewpoint of protecting environment, it should become important.

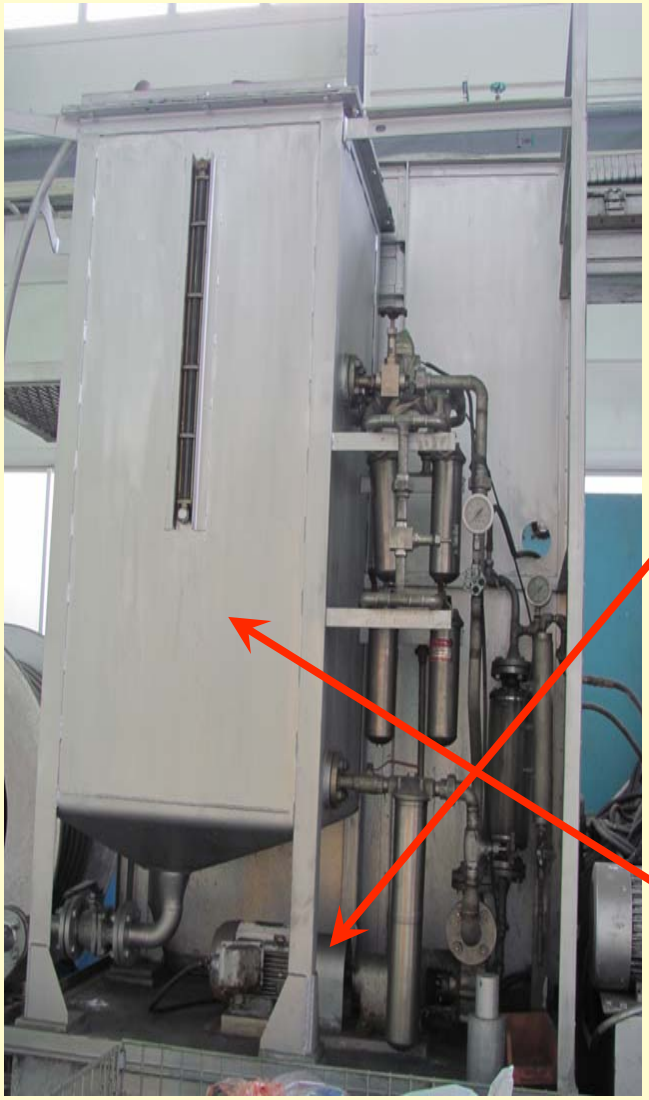
Principle of ECB Treatment





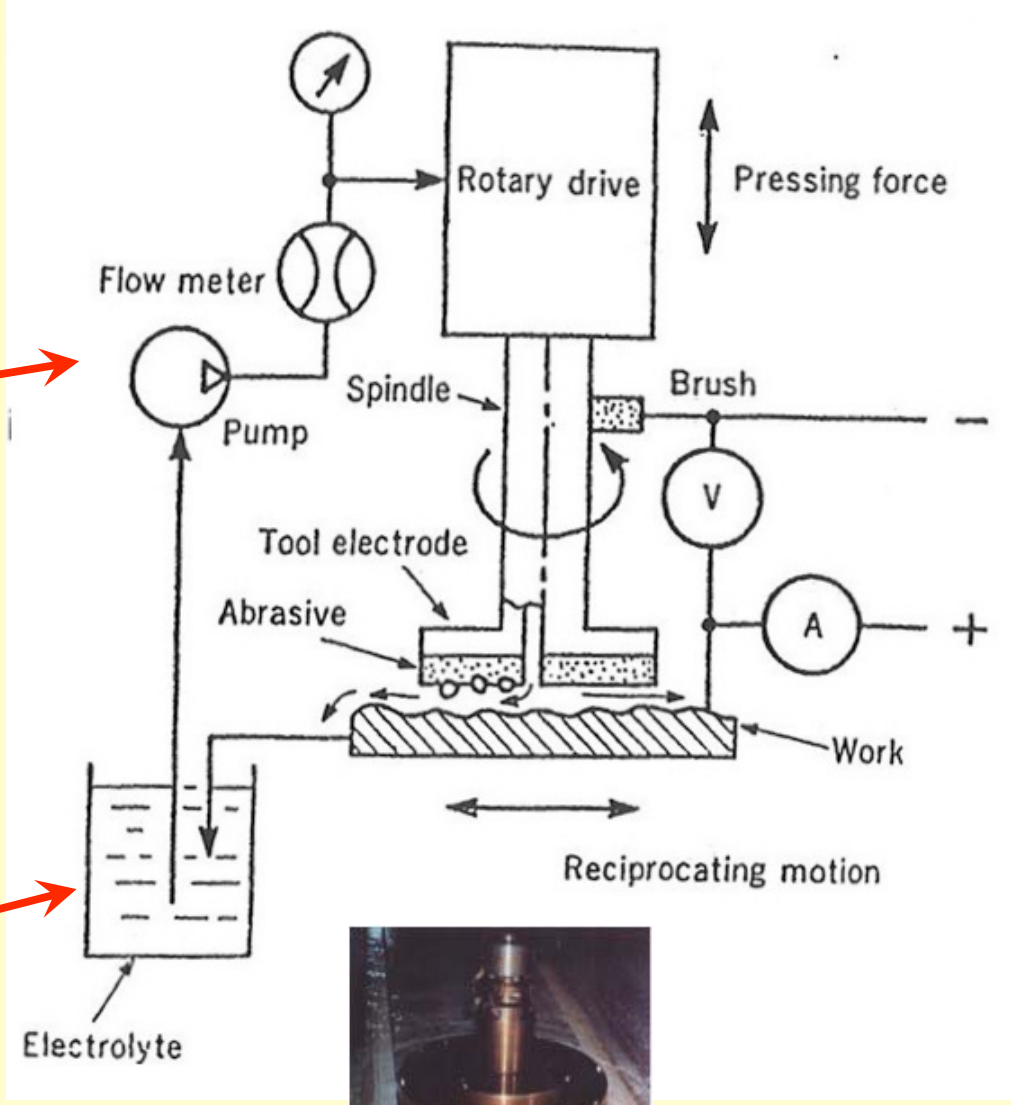
- A rotating disk with abrasive fine particles on nonwoven fabric is pressed against the workpiece.
- An aqueous solution of sodium nitrate (neutral) is supplied in between.
- The disk and the work function as a cathode and an anode, respectively.
- Abrasive : micropowders of alumina, diamond, silica etc.
- Current : a few of mA/cm to a few of 10mA/cm^2 depending on the polishing stages.

ECB Treatment Facility

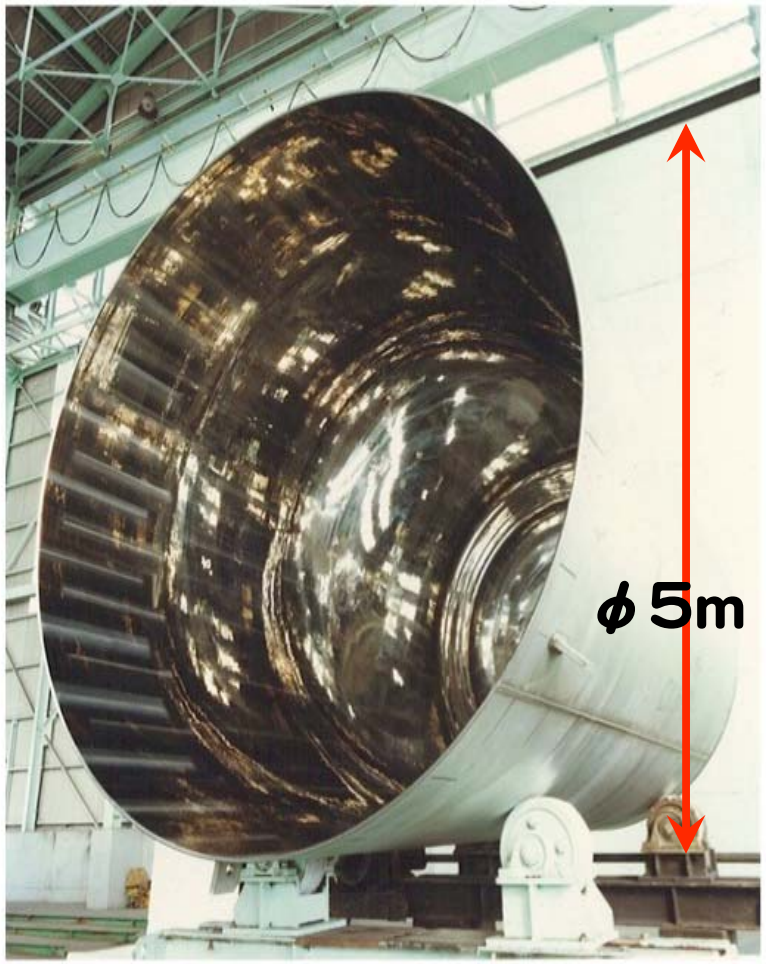


Pump

Electrolyte
Tank (1m³)



Product Examples of ECB Treatment



Max : no limitation, achievement: ϕ600mm*12m
Min : < ϕ4mm*1m or ϕ30mm*4m

Comparison of EP and ECB Treatments

	EP	ECB
Electrolyte	con. HF + H_2SO_4	$NaNO_3$ (20 wt% of
	~45% + 95%	aqueous solution)
Aging of electrolyte	Quick	Very slow
Heat exchanger	Required	Unnecessary
Usage efficiency of electrolyte	Low	High
Strong acid compatibility of facility materials	Required	Unnecessary
Draft chamber	Required	Unnecessary
Alarm and safety systems	Required	Unnecessary
Safety zone and safety wear	Required	Unnecessary

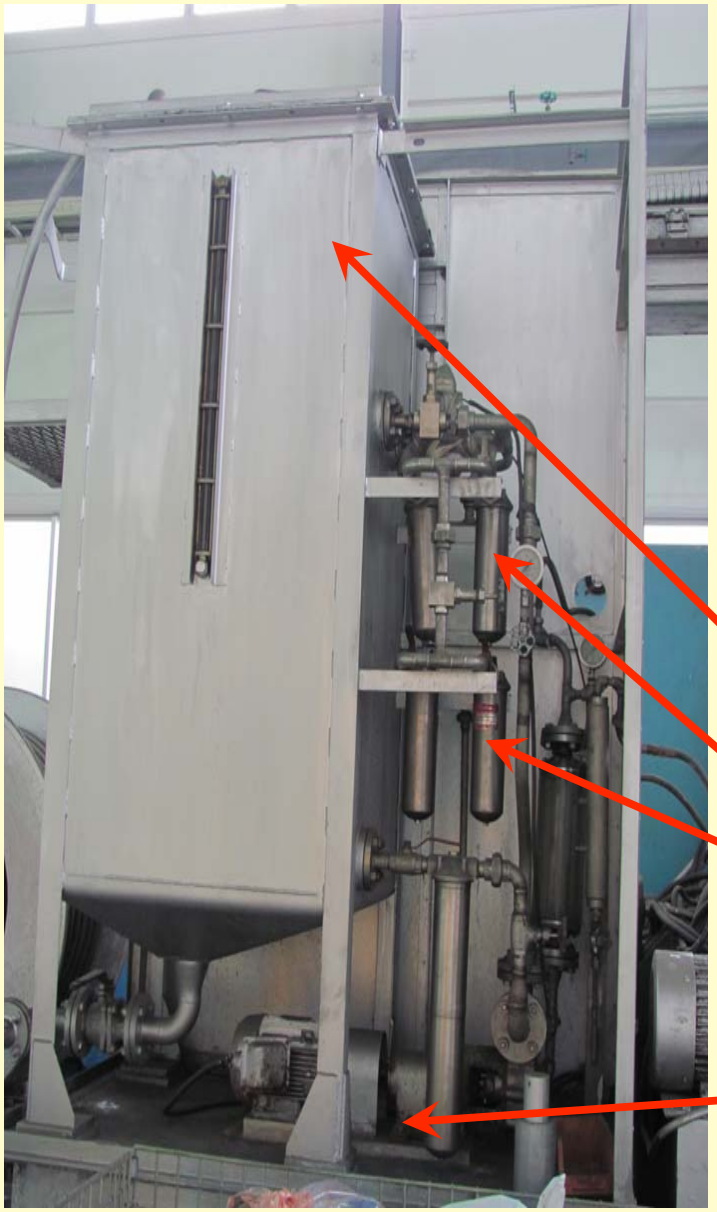
*** Aging of ECB Electrolyte :**

- **The sodium nitrate solution does not age at all even after one year storage unless it is used. This is because any volatile component such as hydrogen fluoride of EP solution is not included in it.**
- **The solution also enables us frequent usage of the same electrolyte. The rough usage efficiency would be an area of 100m^2 per 1 m^3 solution since most of etched metallic component becomes its hydroxide which is solid and be able to be filtered during the solution circulation.**

*** Heat exchanger :**

- **The electrolyte temperature does not affect the polishing performance practically since electropolishing in the ECB technique just assists mechanical buffing. Therefore a heat exchanger is needless in the ECB facility. This is another big advantage of ECB against EP which need somehow sensitive temperature control of EP solution.**

Usage efficiency of electrolyte

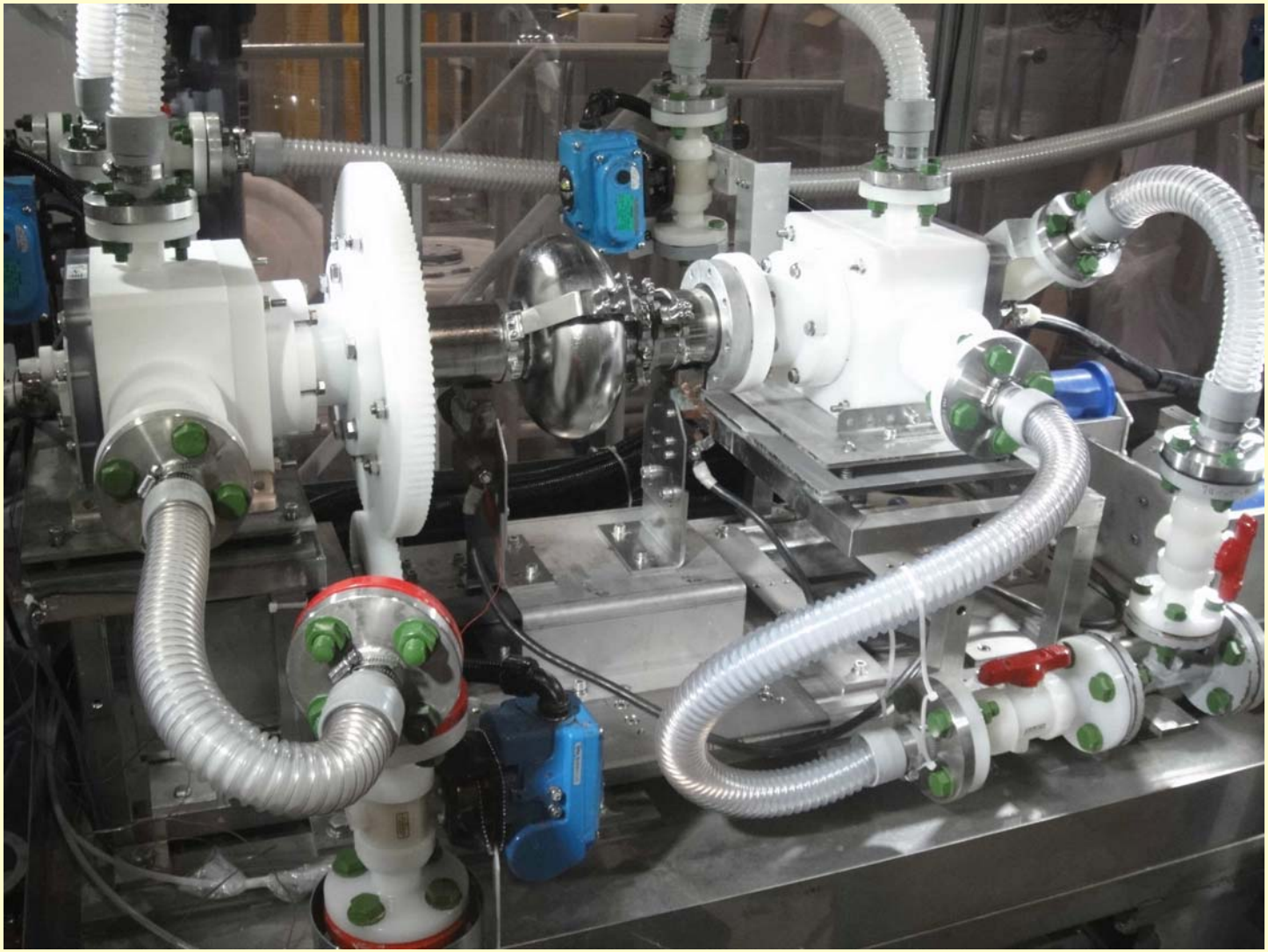


Usage Efficiency :
possible etching area / m^3/200 μm

- EP : a couple of 10 m^2 (KEK)
- ECB : a couple of 100m2 since the most of etched metallic component becomes its hydroxide which is solid and be able to be filtered during the solution circulation.

Draft Chamber, KEK

EB Bench, KEK



EB Bench, KEK

Lots of PTFE etc Parts, Safety Wears, Gloves・・・

EB Facility, J-lab

Safety Wears with Ventilator, Safety Floor

EB Facility, J-lab

Costly Plumbing : Tubes, Valves, Fittings・・・ made of PTFE and Viton

Nevertheless Damaged・・・

Exchange of EP Electrolyte, KEK

From Report of Sawabe san, KEK, 2010-July

- A period of the exchange : July 12～23,2010
- Process : Pulling out old electrolyte → Water washing (Pure water) → High pressure washing(Pure water) → Drying → Pulling in new electrolyte

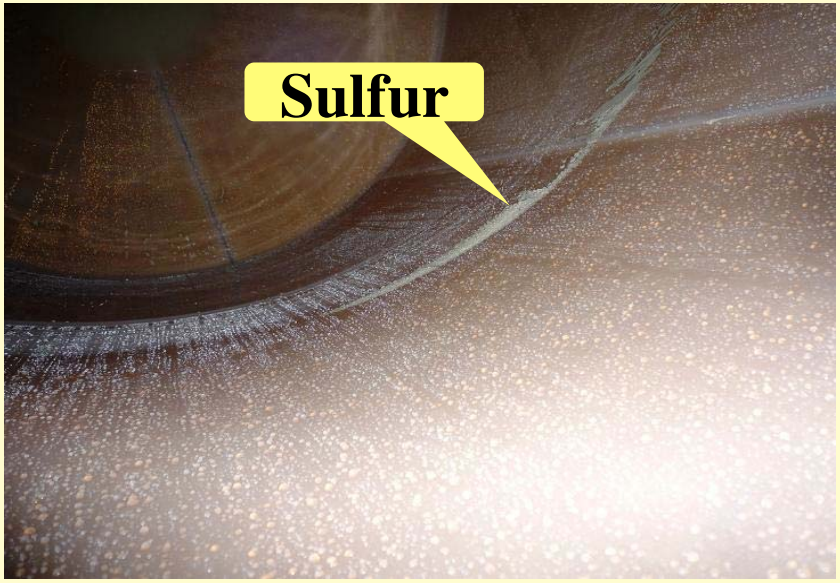
Reservoir tank & Line

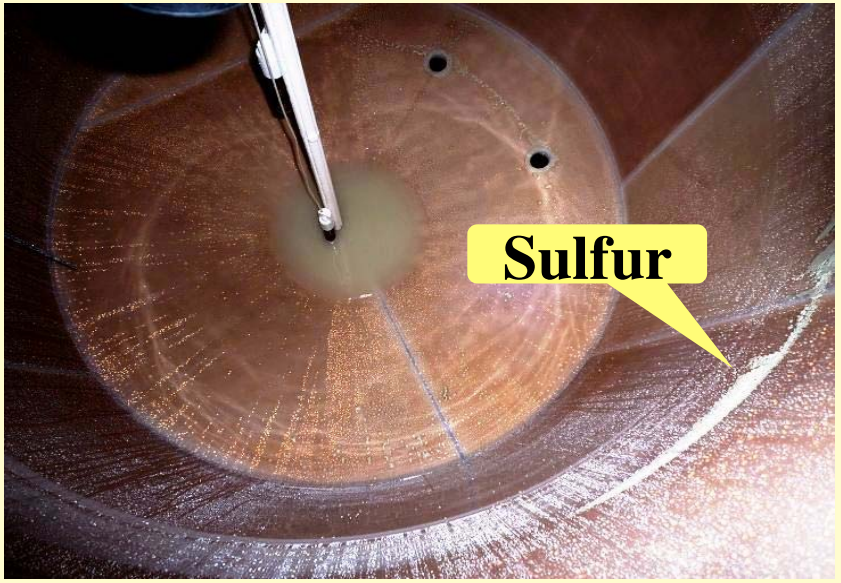
Reservoir tank only

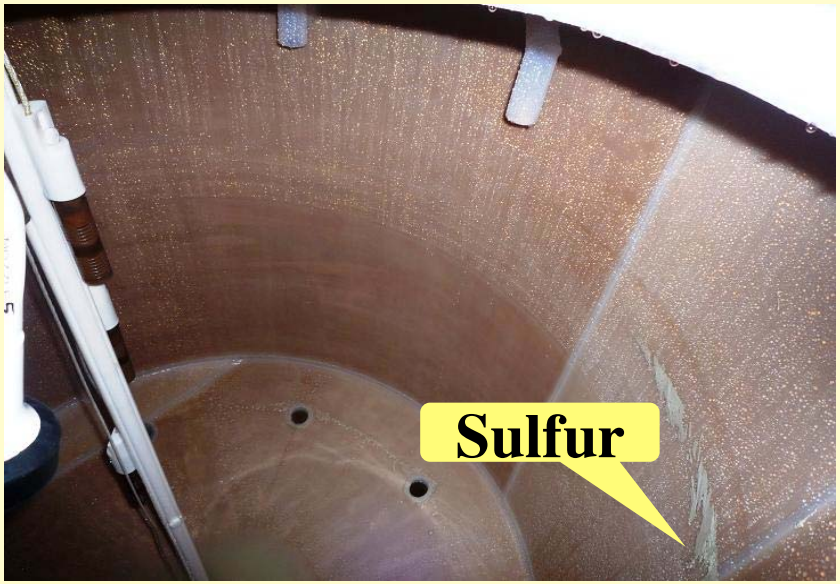
Pulling out old electrolyte

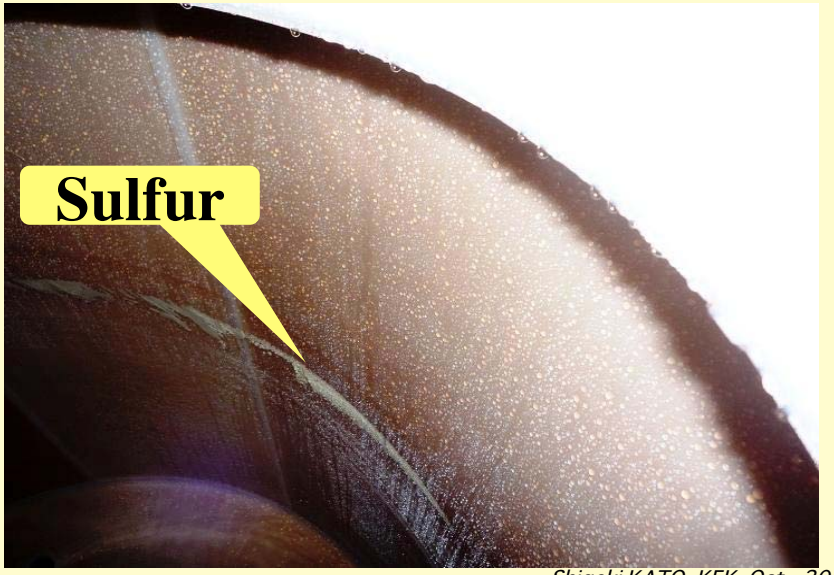
Exchange of EP Electrolyte, KEK cont'd

Before water washing









Exchange of EP Electrolyte, KEK cont'd

During HPR of Acid Tank

After HPR

Exchange of EP Electrolyte, KEK cont'd

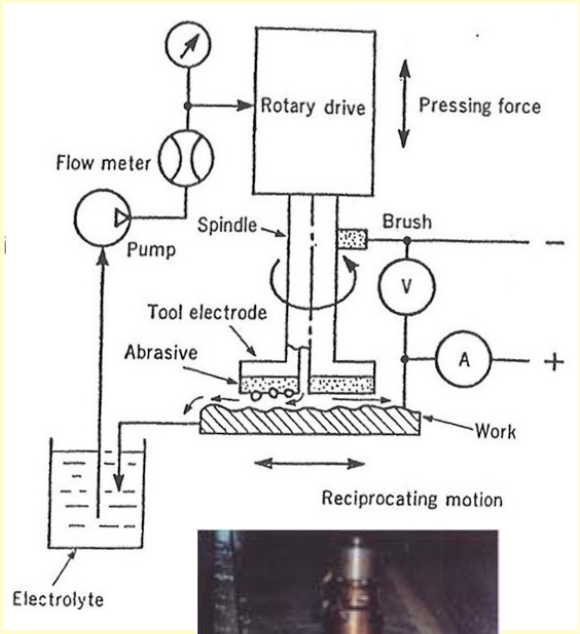
Filling New Electrolyte

Exchange of EP Electrolyte, KEK cont'd

Takeaway of Old Electrolyte from KEK

ECB Treatment Facility

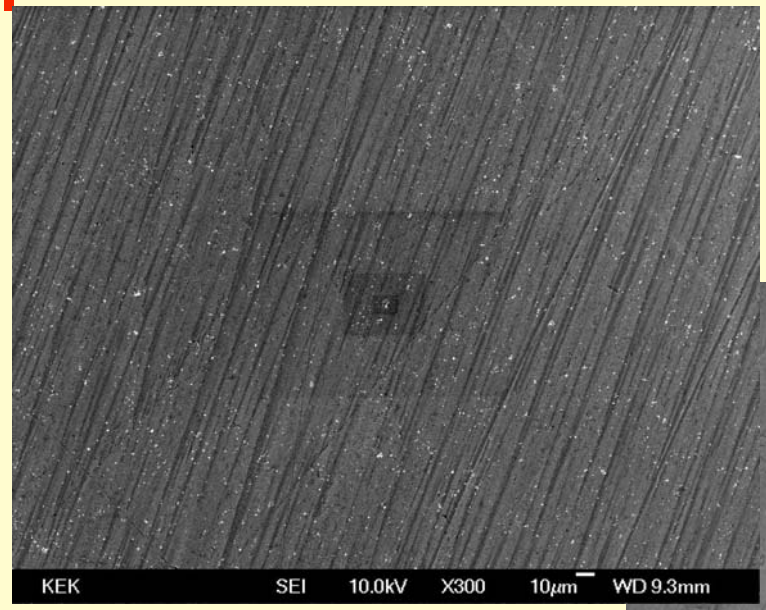
- $NaNO_3$ (20wt% of aqueous solution) : Neutral pH:7
- Strong-acid compatible plumbing and components such as flanges, gaskets made of PTFE, PFA, or HDPE are not necessary in ECB technology at all.
- StSt material can be used for any part.

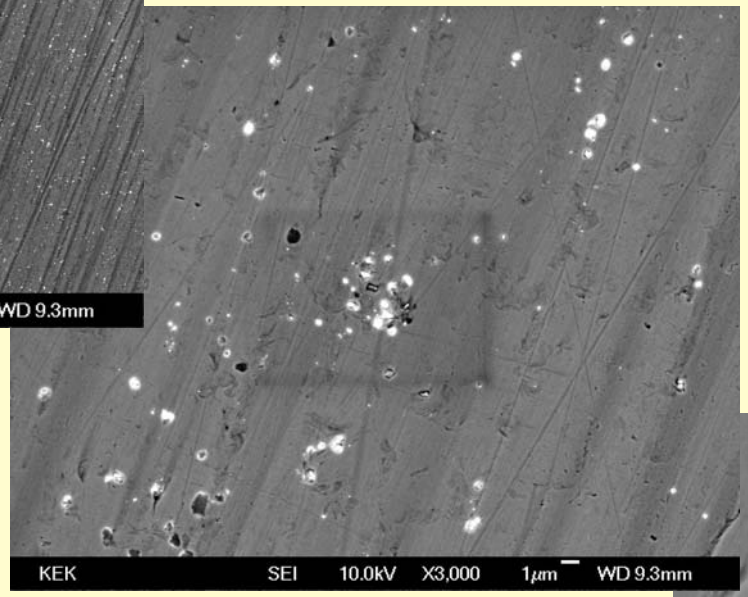


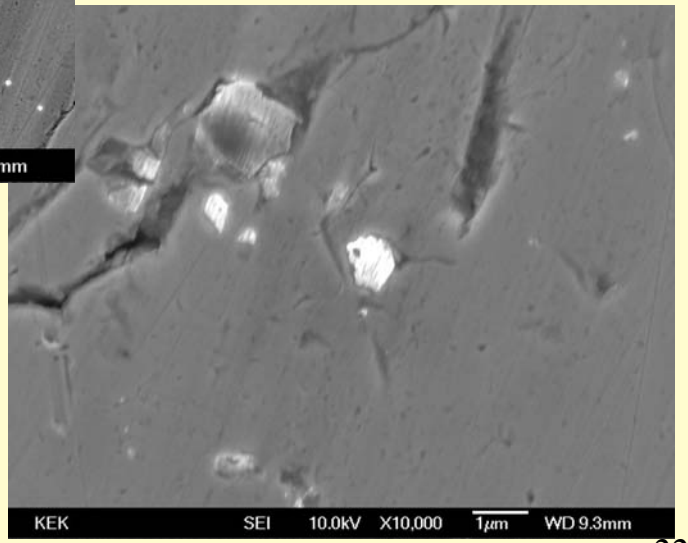
How Good ECBed is Surface?

Analyses of ECBed Sample Coupons

During Attempt to Apply ECB to Nb Surface・・・



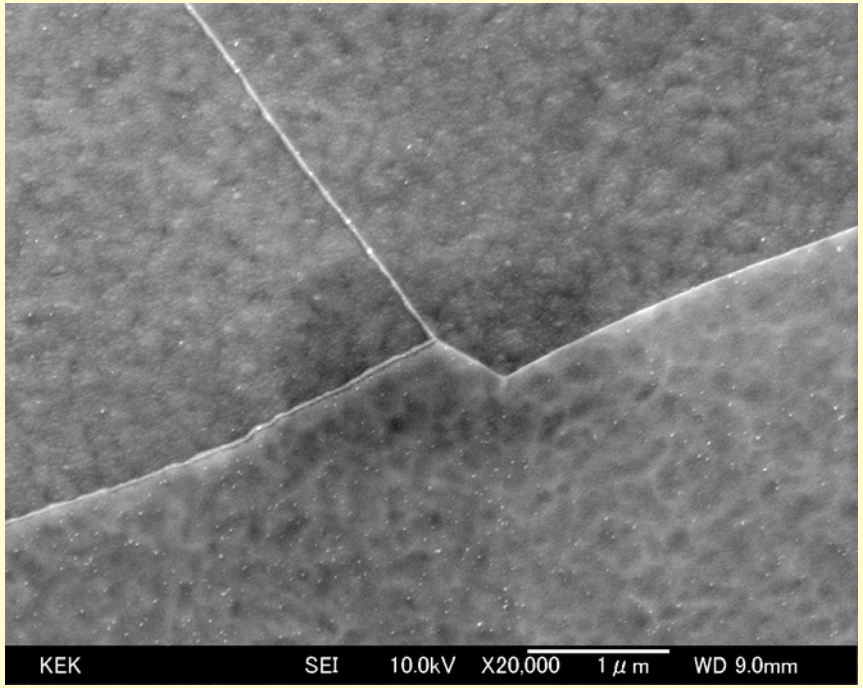


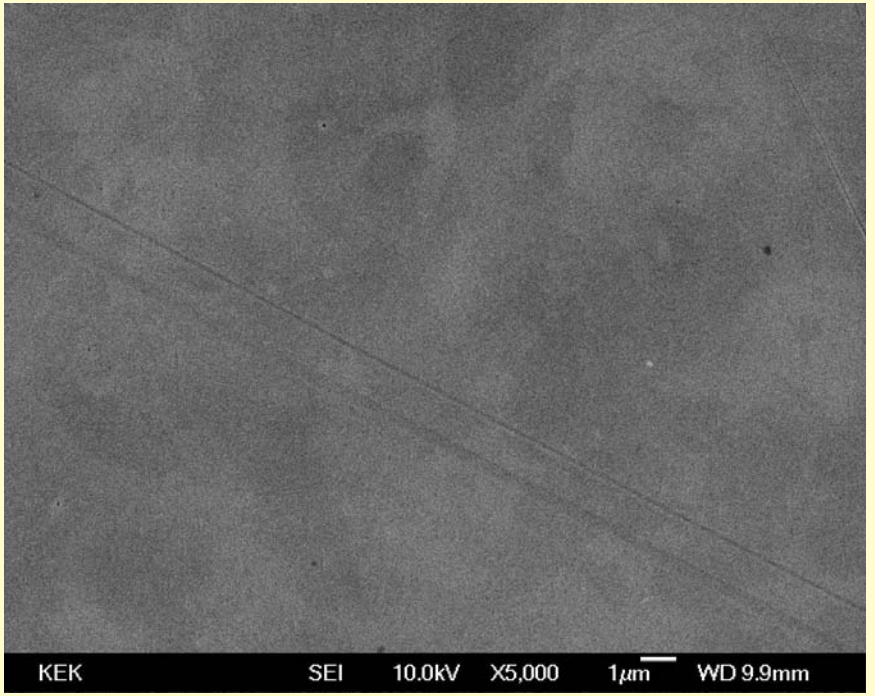


Diamond Micropowders !

Many Parameters Optimized

SEM Images of EPed Surface (left) and ECBed (right)

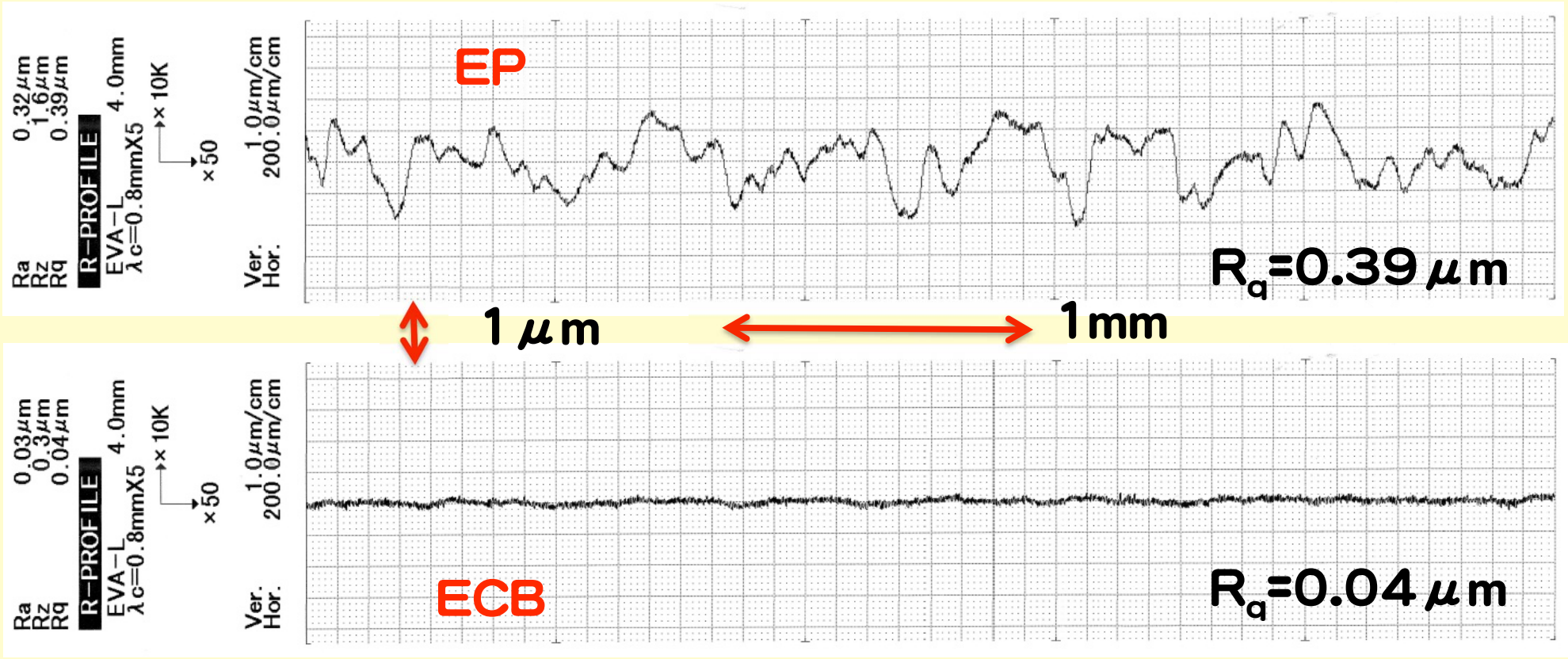




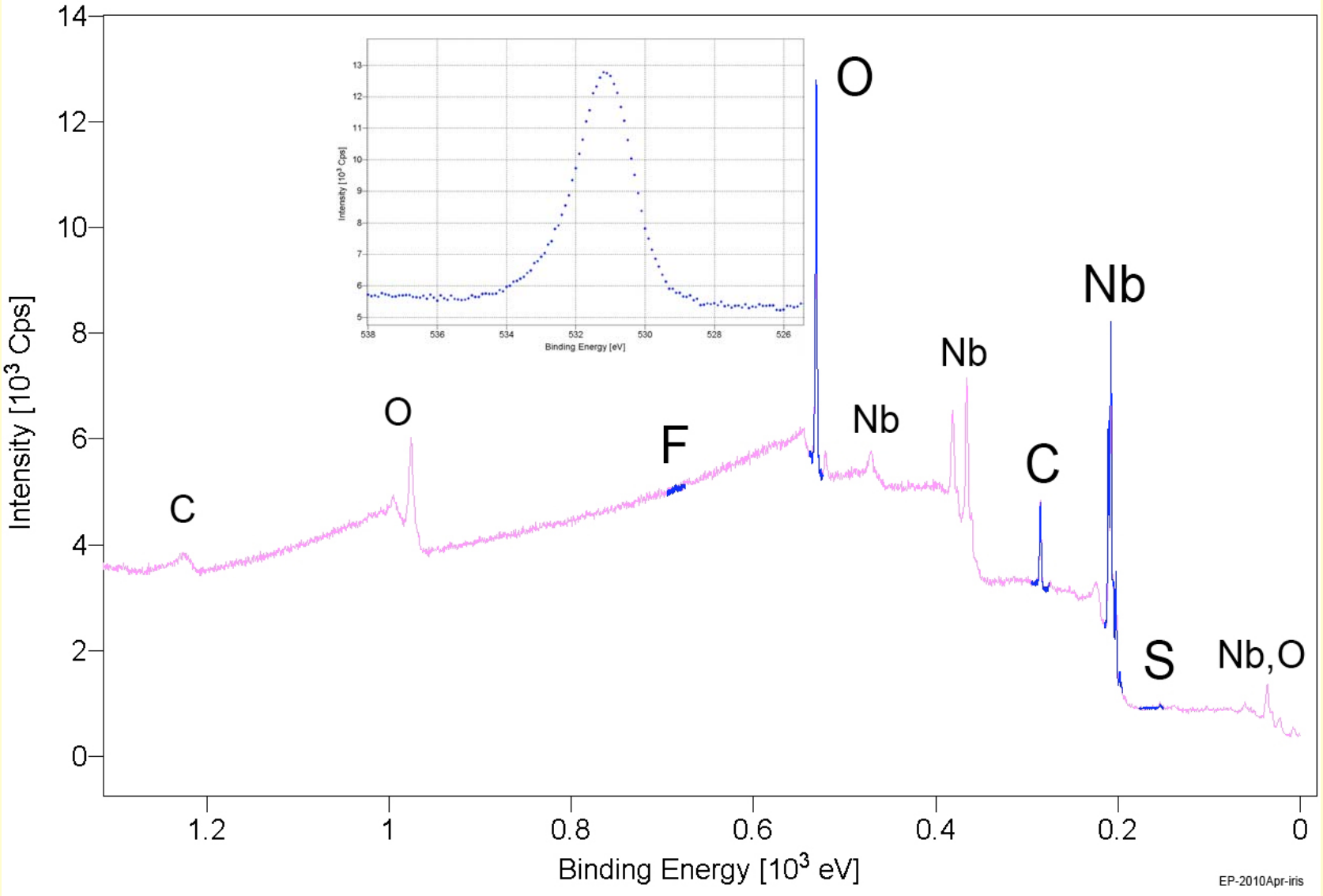
* EP conditions :
- 50mA/cm^2, ~7g/l

* ECB conditions :
- 20 wt% of aqueous solution of sodium nitrate, alumina micropowder of 5μm for coarse polish and silica fine particle of 60 nm for finishing.
- A current density during the ECB was controlled from a few of mA/cm^2 to a few of 10mA/cm^2 depending on the polishing steps.

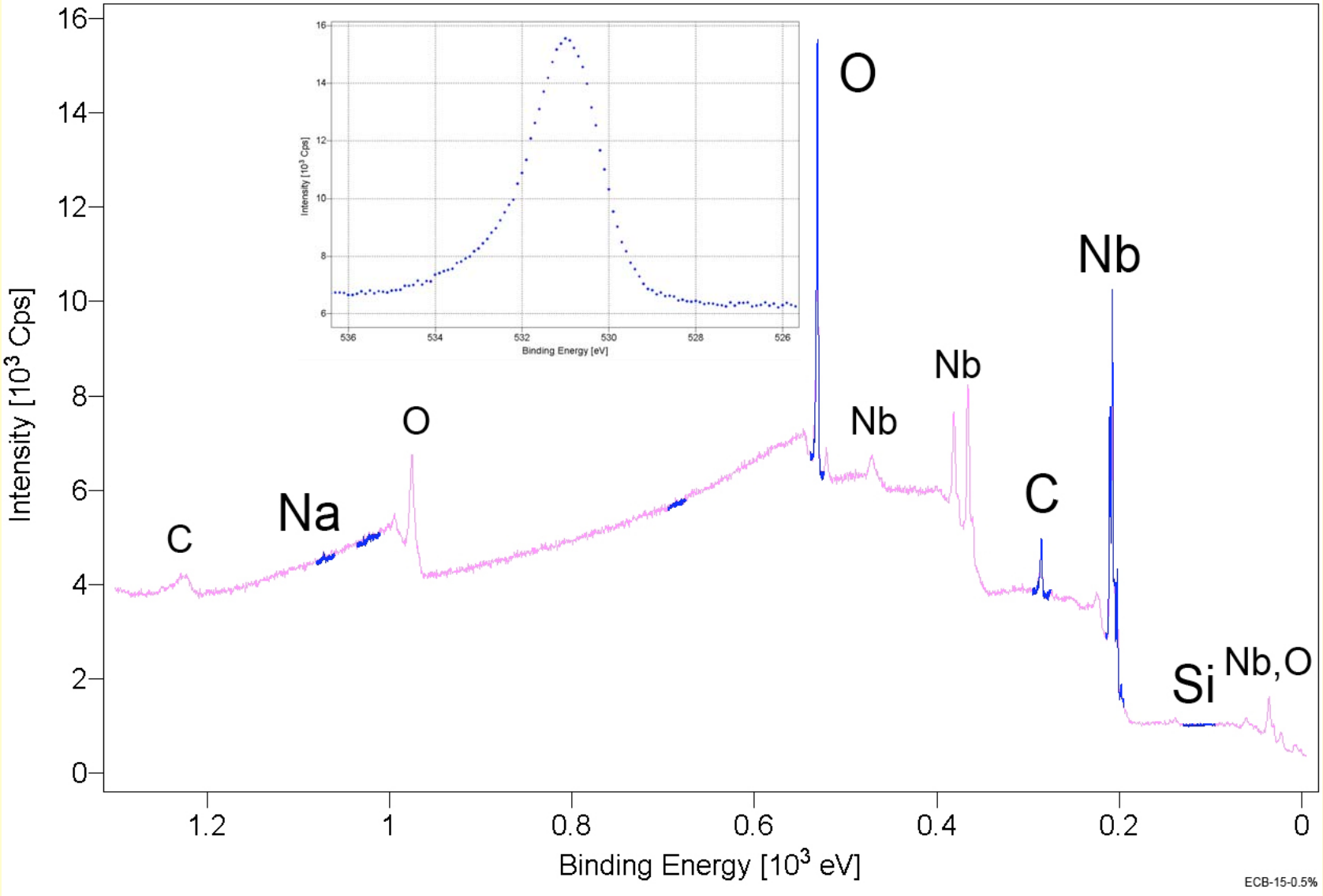
Surface Roughness Measured with Mechanical Surface Profile Meter



XPS Spectra of As-received EPed Nb Coupon



XPS Spectra of As-received ECBed Nb Coupon



Atomic Compositions of As-received Coupons

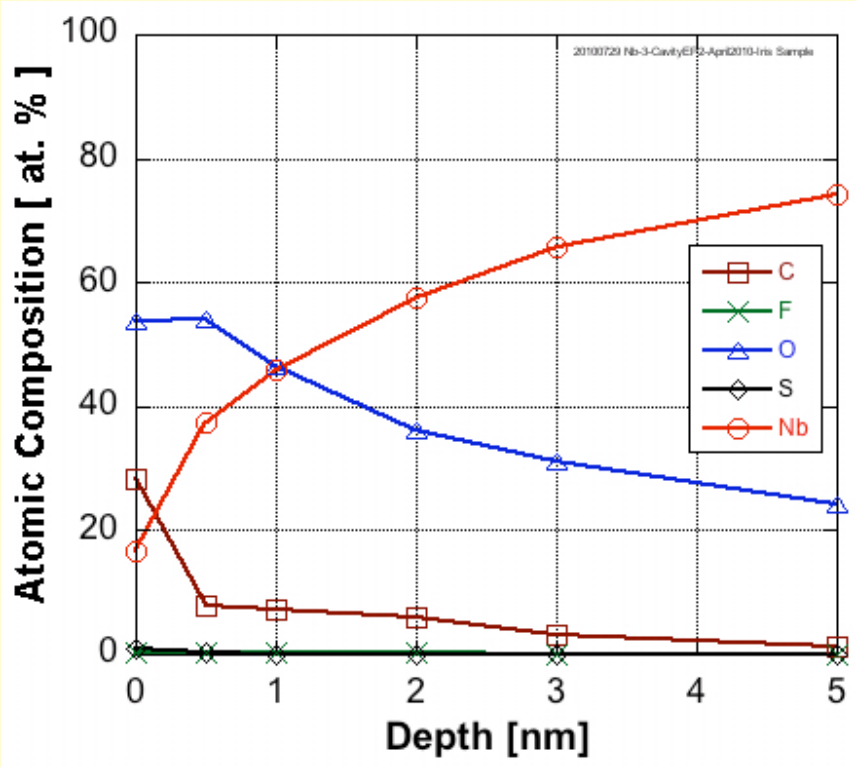
in at.%

	Nb	O	C	Na	S	F	Si
EP	16.8	53.7	28.4	0	1.0	0.2	0
ECB	17.5	59.4	21.9	0.3	0	0	0.9

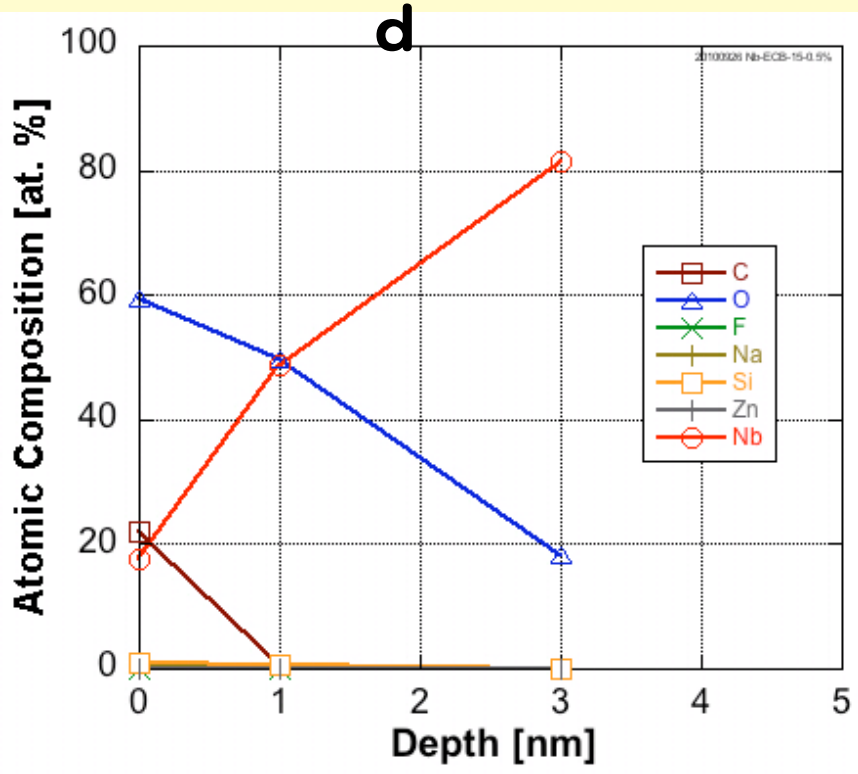
EP : the sources of S and F are obvious.
ECB : the sources of Na and Si can be assigned to be sodium nitrate and abrasive particles of silica in the fine polishing process.

Depth Profiles of As-received Nb Coupons

EPed



ECBed



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Cavity Beam Pipe Sample (test piece)

Longitudinal Welding : EBW
Transverse Welding : LBW

Pass around the piece.

ECBed 1.3GHz Nb Half Cell (test)

Manufacture of 1.3GHz Nb Single Cell Cavity

LBW + ECB

Manufacture of Single Cell Cavity cont'd

Manufacture of Single Cell Cavity cont'd

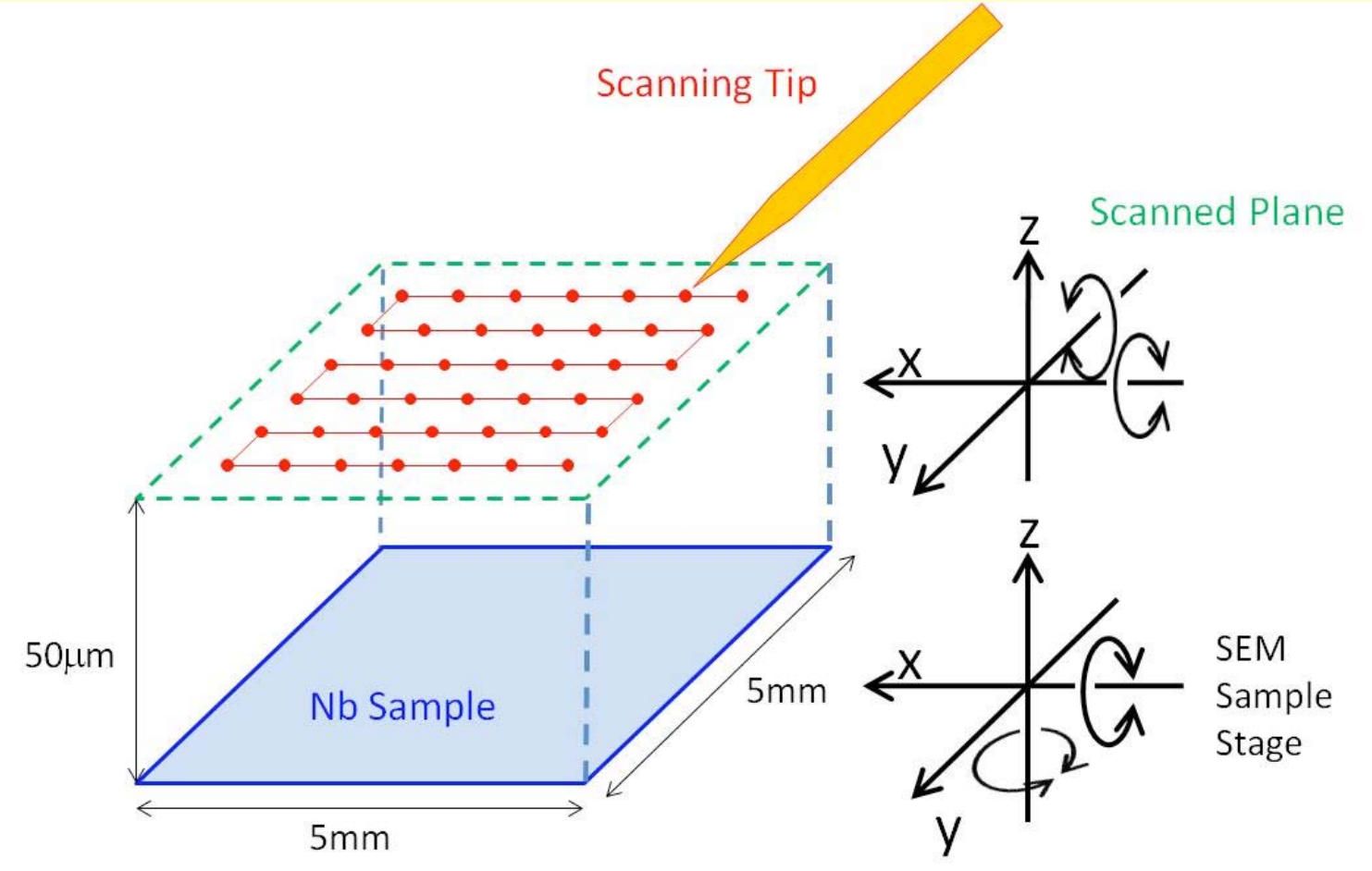
Manufacture of Single Cell Cavity cont'd

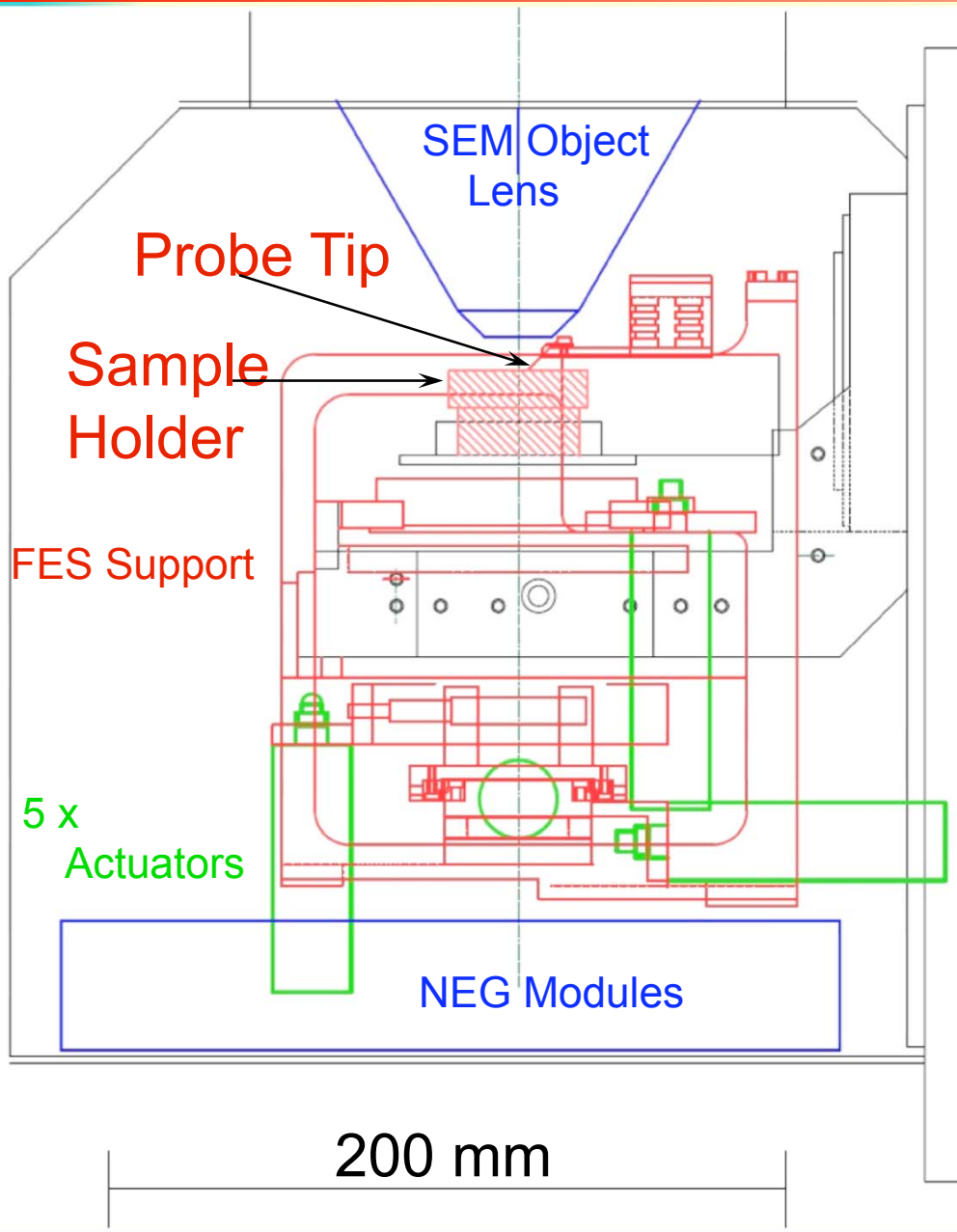
Summary

- ECB can be considered to be a green technology to protect our environment in production of SRF cavities.
- Investigation of a possibility of ECB application to niobium SRF cavity was first made with approach using surface analysis.
- ECB can be fundamentally considered to be a highly efficient or cost-effective green technology in production of SRF cavities.
- The application study of this promising technology has just started and the surface analyses showed a quite low roughness down to around 30nm(Ra) and low levels of residues. Further investigation to reduce abrasive particles is necessary especially with help of high pressure rinsing.
- One single cell cavity newly manufactured is waiting for the ECB application and its vertical test.
- An under assembly field emission scanner will allow to find field emission points with a lateral resolution of sub-micron should enhance improvement of EP and ECB technology.

Field Emission Scanner

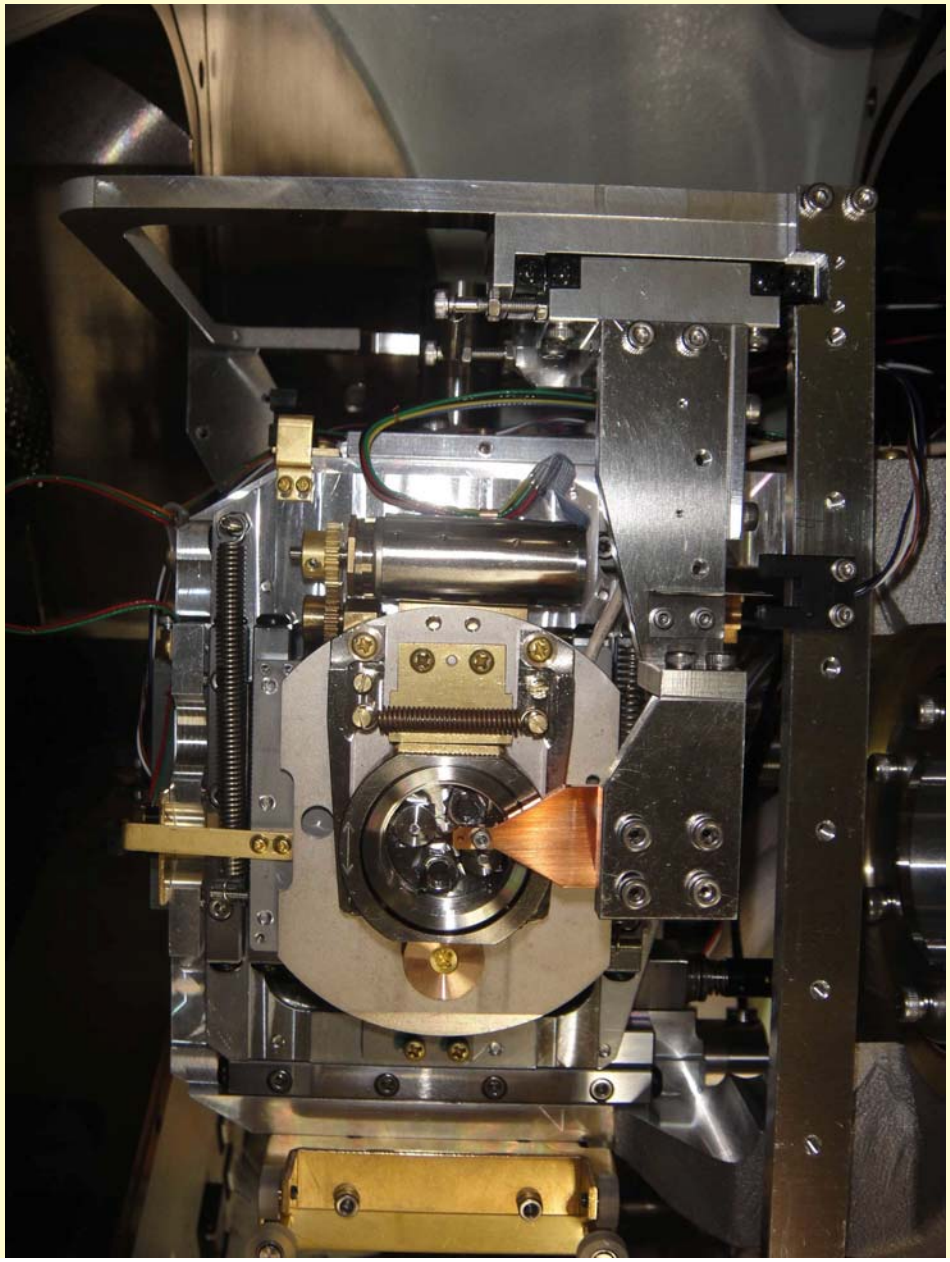
Constant Distance : Scanned Plane

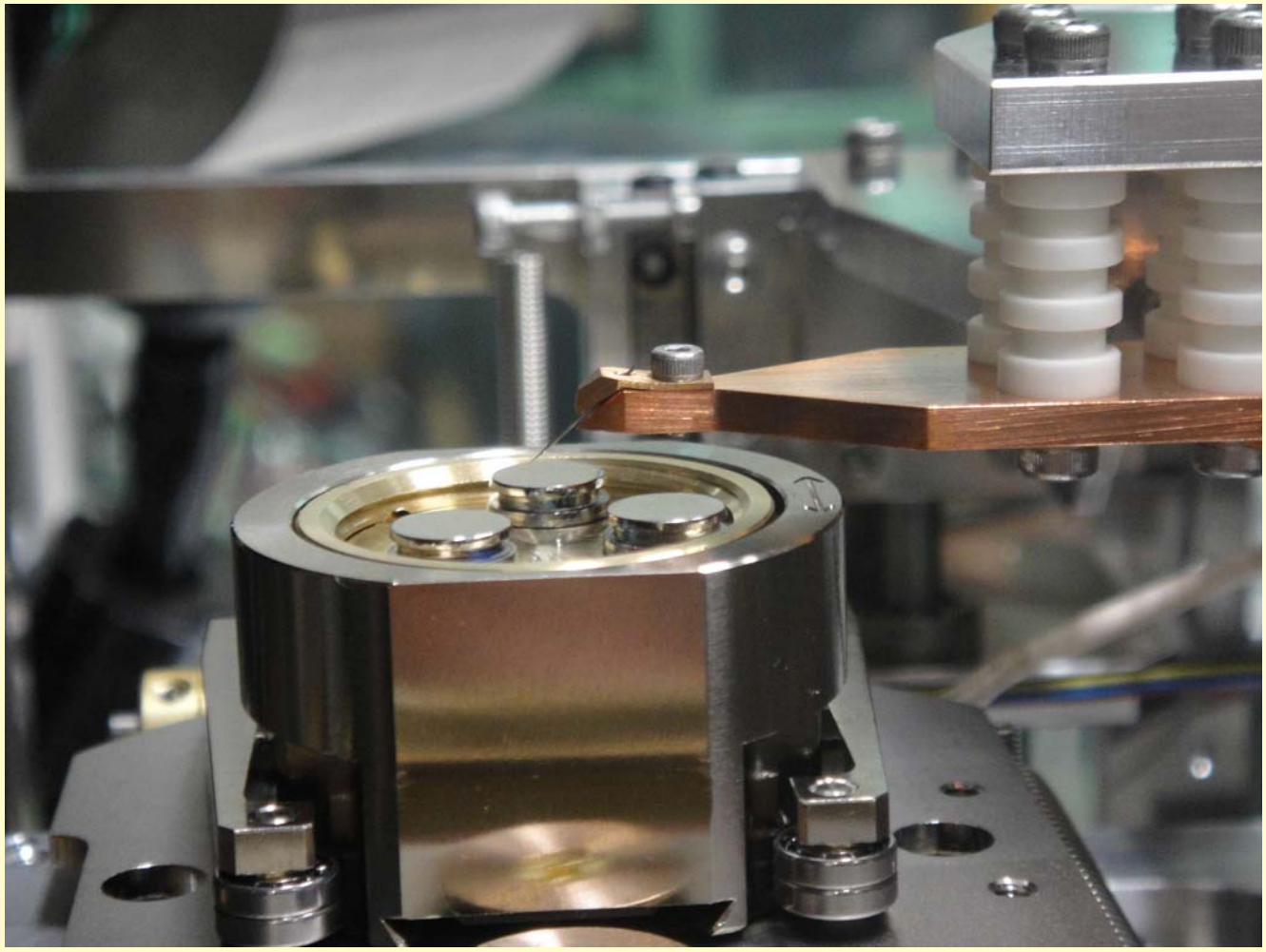




5 Axis Stage

* X, Y, Z : ±10mm
* Step Resolution : 250nm
* 20mm/36s@MaxSpeed (40k steps)
* Tilt : ±3°
* High Voltage : <15kV
* Field Emission Current : > 0.1pA
* Probe Tip : Tungsten
* Sample Size : < φ26





- <5kV/50μm=100MV/m
- Raster Scan over 5mm□
  with help of SEM obserbation

Fin

Thank you for attention!